Using the Relative Risk Model for a Regional Scale Ecological Risk Assessment and Risk Prediction to Management Options of the Squalicum Creek Watershed (WA, USA)

Joy Chen
     Jones and Stokes

Abstract

A two-part ecological risk assessment of the Squalicum Creek watershed (SCW) was conducted using the Relative Risk Model (RRM). The objectives of this assessment were to:

(1)   Rank multiple stressors and land uses according to their relative contribution of risks to the endpoints.

(2)   Determine the relative risks of each habitat and endpoint in the SCW.

(3)   Predict the effects of decision options on the watershed.

The RRM, a rank-based method, was used due to its ability to quantify risks in multiple geographical-scale areas with multiple stressors, habitats and receptors. Results from Part I showed that the risk regions with the most overlapping of relatively high rank stressor sources and habitats, accompanied by the specific source-endpoint exposure pathways, were found to have the highest risk. Salmonids were found to be at relatively low risk because of limited habitat due to impassable culverts. Results from Part II indicated that in most cases, stressor sources and stressors reduction could lower more risk to endpoints than habitat creation. The assessment results enable various authorities to have a common set of priorities for the parcels and the RRM allows the decision makers to predict the effects of management decisions on the system.

Extended Abstract

We conducted a two-part ecological risk assessment. The goals of the first part of the assessment were to: (1) determine the risks from anthropogenic sources to the Squalicum Creek watershed and (2) determine the utility of the Relative Risk Model (RRM) on small-scale (62 km^2) ecological systems. The purpose of the second part of the assessment was to test the utility of the RRM as a predictive tool in watershed management.

Human land uses have led to various adverse effects in the Sqaulicum Creek watershed. Management decisions within the watershed are currently made on a case-by-case basis that only addresses the ecological effects of individual parcel development. These studies ignore effects resulting from the interactions between sources and receptors of different parcels. In Part I of the assessment, we conducted an ecological risk assessment of the Squalicum Creek watershed using the RRM. We used the RRM because of its ability to incorporate stakeholders' values in quantifying risks in multiple geographical-scale areas with multiple stressors, habitats and receptors.

The RRM is a ranked-based, regional-scale ecological risk assessment method. It was first developed in 1997 for an ecological risk assessment of Port Valdez, AK (Landis and Wieger 1997). The methodology was successfully applied to a number of other risk assessments of ecosystems with various scales, stressors and endpoints (Landis et al. 2000; Obery and Landis 2002; Walker et al. 2001). The study conducted by Thomas et al. (in progress) further confirmed the utility of the RRM as a tool to analyze alternative decisions.

In Part I, we identified the sources and stressors that contributed the most risk to the watershed and identified the habitats, endpoints and risk regions that are most at risk in the study area. We also conducted an uncertainty analysis to show what the uncertainties are and suggested methods to reduce these uncertainties. Results from Part I integrate the effects of multiple individual decisions and enables various authorities to have a common set of priorities for the parcels. Study results showed that the RRM was applicable to the Squalicum Creek watershed with few modifications from the original model. Risk regions with the most overlapping of relatively high rank stressor sources and habitats, accompanied by the specific source-endpoint exposure pathways, were found to have the highest risk. Uncertainties were due to (1) stochastic sources, (2) ignorance, and (3) error.

A good management tool for regional scale ecosystems requires the ability to predict the future conditions of the system and the effects of management decisions on the system. In Part II of the assessment, we tested the utility of the RRM as a predictive model for the effects of decision options on the Squalicum Creek watershed. We used the RRM generated in Part I to predict the effects of various decision options to the Squalicum Creek watershed. The methodology involves seven steps:

1. Determine the current condition of the study area.
2. Define a list of decision options.
3. Recalculate the model input data.
4. Re-rank the new input data.
5. Alter the exposure pathways to generate new risk scores.
6. Calculate the change in risk scores from the original RRM result.
7. And analyze and compare the results for the different decision options.

We included both positive and negative action decision options in this study along with a no-action option. Study results indicated that the reduction of stressor sources and stressors could reduce the most risk to endpoints with the exception for the salmonids endpoint. Removing culverts opened up new habitats for the salmonids and as a result increased their risk due to increased exposure.

Our study shows the utility of the RRM as a predictive model for the effects of decision options on the study area. The RRM is a good tool for predicting the effects for all decision options except when the decision option involves increasing or creating habitats. The model prediction demonstrated a clear movement of the endpoints in response to the decision options. The prediction enables risk managers to select the decision option that would produce the closest result to their management goal with a relatively small amount of uncertainties associated with the use of the RRM as a predictive tool. A few of these limitations include the inability of the model to account for seasonal patterns and migratory patterns of endpoints within a risk region and the potential uncertainty associated with sensitive habitats. This RRM for the Squalicum Creek watershed can be greatly improved if studies were to be conducted to confirm the endpoints position. Modifications to the model to incorporate the model limitations identified in this study, such as the inability to account for the dilution property of increased habitats towards a fixed amount of stressors, could also improve the accuracy of the model significantly.

References

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